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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
PREVENTION, PESTICIDES
AND TOXIC SUBSTANCES

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MEMORANDUM

SUBJECT: Linuron RED Candidate - EFGWB Science Chapter

TO: Linda Propst, Product Manager #73
Peg Perreault, Product Reviewer
Reregistration Branch, Section III
Special Review and Reregistration Division (7508W)

FROM: William R. Effland, Ph.D. William R. Effland
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The attached document contains the Environmental Fate and Groundwater Branch (EFGWB) Science Chapter for the List A Reregistration Eligibility Document (RED) for Linuron. The RED Science Chapter is divided into five sections -- Executive Summary; Summary of the

Environmental Fate Assessment, Use Patterns and Environmental Fate Data Requirements; Technical Summaries in support of the Environmental Fate data requirements; Assessment of Linuron Detected in Ground Water; and Recommendations with Table A which summarizes the generic data requirements.

Acceptable information from environmental fate studies with respect to persistence of linuron under laboratory conditions has been reviewed. These studies (degradation and metabolism processes) indicate linuron is moderately persistent with degradation principally through biotic processes such as aerobic and anaerobic metabolism in contrast to abiotic processes such as hydrolysis and photolysis. The information on mobility in the environmental fate data base is either partially acceptable or supplemental.

At this time, the following environmental fate data requirements are not fulfilled -- Leaching/Adsorption/Desorption (163-1) and Terrestrial Field Dissipation (164-1). The Leaching/Adsorption/Desorption studies are required to provide information on mobility of the pesticide and major degradates. The Leaching/Adsorption/Desorption (163-1) data requirement is not fulfilled because information on the mobility of the major linuron degradates formed under anaerobic conditions (desmethoxy linuron, desmethoxy monolinuron, norlinuron) is not currently available. Studies of terrestrial field dissipation provide data to evaluate patterns of pesticide residue dissipation in field environments. The Terrestrial Field Dissipation (164-1) studies are partially acceptable at this time or supplemental because the patterns of formation and decline of total linuron residues could not be assessed; and field test procedures and analytical methodology were not completely described.

The additional data required for the mobility and terrestrial field dissipation studies will be used to help determine the principal routes and rates of dissipation of linuron and its significant degradates under typical use conditions. The mobility data (partitioning coefficients, K_ds) will be used to assess the mobility of the primary degradates of linuron and may be applied to complete computer simulation modeling of the fate and transport of the primary degradates. Additional data required for the terrestrial field dissipation studies are necessary to assess the rates and pathways of dissipation of parent linuron and its primary degradates. Information on the persistence, mobility, and dissipation pathways of several primary degradates of linuron is not currently available; therefore, the attached environmental fate assessment must be considered incomplete and tentative.

The environmental data base for <u>parent linuron</u> is essentially complete. Based on current information in the environmental fate data base, linuron is moderately persistent and relatively immobile. The principal route of dissipation of linuron is through biotic processes such as aerobic and anaerobic microbial degradation. Abiotic processes such as hydrolysis, photolysis, and volatilization do not appear to be significant routes of dissipation. Review of partially acceptable and supplemental information on the mobility of linuron suggests that linuron is primarily sorbed to soil organic matter. Information obtained from the environmental fate studies indicates the potential for linuron to leach to ground water is limited by sorption and microbial degradation. Increased mobility of linuron may occur under specific environmental conditions (e.g., coarse textured soils; soils with low organic matter levels). For this reason, EFGWB recommends that prospective ground-water

monitoring studies be conducted to determine the environmental fate of linuron in both vulnerable and representative use conditions. EFGWB also recommends the addition of a ground-water advisory statement to the linuron label, consideration of linuron for restricted use classification based on ground-water concerns, additional label restrictions, and the establishment of criteria for additional mitigation, suspension, and voluntary cancellation. Linuron, present as either dissolved species and/or sorbed to entrained sediments in surface runoff, could potentially also be transported to surface water bodies (lakes, streams, etc.).

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MEMORANDUM

SUBJECT: Revision to EFGWB RED Chapter on Linuron

TO: Linda Propst, Product Manager #73
Peg Perreault, Product Reviewer
Special Review and Reregistration Division (7508W)

FROM: Estella Waldman, Hydrologist
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THRU: Elizabeth Behl, Section Head
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Henry M. Jacoby, Branch Chief
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Recent information from John Redden and Debra Edwards (Health Effects Division (HED) of OPP) has necessitated a revision of the EFGWB Registration Eligibility Document for linuron. According to HED, the reference dose for linuron should be 0.008 mg/kg/day instead of 0.002 mg/kg/day (the latter is the reference dose cited in the original document). Using this new reference dose, the estimated lifetime Health Advisory for linuron in drinking water can be calculated as follows:

$$\text{lifetime HA} = \frac{(\text{RfD})(70\text{kg})}{(2\text{ L/d})} = \frac{(0.008)(70)(0.2^*)}{(2)}$$

$$\text{lifetime HA} = \frac{0.056\text{ mg/L}}{10^*} = 6\ \mu\text{g/L}$$

(Reference Dose from a one-year dog feeding study)
(* Assumption that 20 percent of the linuron consumed by an adult is from drinking water)

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(** 10-fold safety factor for Group C carcinogen)

Linuron has been placed in Cancer Group C (unquantified) indicating that it is a possible human carcinogen. Using the reference dose that was originally given to EFGWB, the lifetime HA was calculated to be 1.4 μg/L.

Linuron has been detected in ground water in four states including Georgia, Missouri, Virginia, and Wisconsin at levels ranging up to 5.00 μg/L (Hoheisel et al., 1992). A review of the studies in which the ground water detections were reported gave the following results:

1. Georgia

   Detections in ground water were solely from STORET which did not allow a detailed review. Concentrations of linuron ranged from 1 to 5 μg/L (ppb).

2. Missouri

   Rural private wells in agricultural areas of Missouri were monitored for pesticide residues. Linuron was detected at concentrations ranging from 0.5 to 1.9 μg/L (Sievers and Fulhage, 1989a and 1991). In another study conducted in Missouri (Sievers and Fulhage, 1989b), linuron was also detected in ground water in rural agricultural wells at levels ranging from 0.48 to 0.9 μg/L. The study examined ground-water quality in eight major agricultural areas in the state, without regard to the vulnerability of the soils to leaching, nor to areas of high linuron use.

   Dennis Sievers (personal communication, 1994) related to the GWTS that there were some interference problems with the mass spectrometer detector due to sulfur and organic matter. Mr. Sievers was very confident regarding the linuron detections above 1 μg/L, but less confident with the detections reported below 1 μg/L. No information was provided about the wells, depth to ground water, or detection limits.

3. Virginia

   Eight monitoring wells and four household wells were sampled for a suite of pesticides including linuron (Mostaghimi, 1992). There were no indications of point-source contamination or problems with the wells during the study. Linuron was detected in 50% of the monitoring wells (4 of 8 wells) at levels ranging from 0.35 to 1.31 μg/L. The extensive QA/QC plan for the sampling program and GC analysis provided a high degree of confidence for these detections.

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4. Wisconsin

In a Wisconsin study (Postle and Brey, 1991), monitoring wells were located in areas that were highly vulnerable to ground-water contamination. All detections were from areas with normal field use conditions. Linuron was detected at one site at concentrations that ranged from 1.3 to 2.7 μg/L.

Linuron exhibits some of the properties and characteristics associated with chemicals that have been detected in ground water. Linuron is a persistent chemical with an aerobic soil metabolism half-life that ranges from 84 to 91 days (12 to 13 weeks). In addition, its field dissipation half-life has been reported to range from a minimum of 57 days to a maximum of 100 days ($\approx$8 to $\approx$14 weeks, respectively). Based on its persistence, linuron use may have a significant impact on ground-water quality.

Because linuron is persistent and may be mobile under certain environmental conditions, it has the potential to significantly impact ground-water quality at levels that may affect human health. To date, linuron residues have been detected in ground water at levels up to 80 percent of the estimated lifetime Health Advisory level. Potential concentrations of linuron in ground water are not likely to exceed the other risk-based Levels of Concern for ecological effects (see Figure 1a).

Linuron Exceeds the Following Levels of Concern for Ground Water:

♦ **GROUND-WATER QUALITY.** Linuron has been detected in ground water in Georgia, Missouri, Virginia, and Wisconsin. Considering the widespread use of linuron and its environmental fate characteristics, EFGWB is concerned about the degradation of water quality that might occur in linuron use areas.

♦ **HUMAN HEALTH.** Linuron residues have not been detected in ground water at levels which exceed the estimated lifetime Health Advisory. However, residues have been detected at levels up to 80 percent of the estimated lifetime Health Advisory. To date, no information is available about the degradates in ground water, but additional information on the persistence and mobility of the degradates has been requested in the EFGWB Registration Eligibility Document. If the toxicity of the three degradates is similar to the parent, the combined concentrations of parent linuron and its degradates in ground water may greatly exceed the levels of concern for human health.

RECOMMENDATIONS

Because linuron exceeds certain Levels of Concern for ground water, EFGWB recommends the following:

1. Linuron residues have been detected in ground water. Therefore, all product labels should carry the following advisory:

   - "This chemical is known to leach through soil into ground water under certain conditions as a result of agricultural use. Use of this chemical in areas where soils are permeable, particularly where the water table is shallow, may result in ground-water contamination."

2. EFGWB recommends that prospective ground-water monitoring studies be conducted for linuron. In order to better define the conditions that influence the movement of this chemical to ground water, two studies should be conducted to characterize linuron use. Study areas should include those with coarse-textured soils low in organic matter, and those more representative of typical linuron use areas.

3. Linuron meets the persistence and mobility triggers for possible classification as a restricted use chemical for ground-water concerns. EFGWB recommends that linuron be considered for classification as a restricted use chemical based on ground-water concerns.

4. Linuron has been detected in ground water at levels up to 80 percent of the estimated Health Advisory. The registrant should determine the areas that are vulnerable to ground-water contamination by linuron, and recommend label restrictions.

5. The registrant and EPA will agree, as a condition of reregistration eligibility, to establish criteria for additional mitigation, suspension, and voluntary cancellation as a consequence of monitoring study results.

REFERENCES

Hoheisel, C., Karrie, J., Lees, S., Davies-Hilliard, L., Hannon, P., Bingham, R., Behl, E., Wells, D., and E. Waldman. 1992. Pesticides in Ground Water Database - A Compilation of Monitoring Studies: 1971-1991, EPA 734-12-92-001, September 1992.

Mostaghimi, S. 1992. Watershed/Water Quality Monitoring for Evaluating BMP Effectiveness, Virginia Polytechnic Institute and State University.

Postle, J.K. and K.M. Brey. 1991. Results of the WDATCP Groundwater Monitoring for Pesticides, Wisconsin Department of Agriculture, Madison, WI.

Sievers, D.M. and C.D. Fulhage. 1989a. Quality of Missouri's Agricultural Groundwater Region II Sampling, University of Missouri.

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Sievers, D.M. and C.D. Fulhage. 1989b. Quality of Rural Well Water, North Missouri, Special Report 402, University of Missouri at Columbia, September 1989.

Sievers, D.M. and C.D. Fulhage. 1991. Quality of Missouri's Agricultural Groundwater Region II Sampling, Missouri Department of Natural Resources.

Sievers, Dennis. 1994. Personal communication.

ENVIRONMENTAL FATE SCIENCE CHAPTER FOR LINURON REREGISTRATION

SECTION 1. EXECUTIVE SUMMARY

Linuron (3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea), a pre- and post-emergent herbicide, is used for control of many annual grasses and broadleaf weeds in terrestrial food, terrestrial non-food, and forestry use areas. Following review of acceptable, partially acceptable and supplemental information in the environmental fate data base, linuron appears to be moderately persistent and relatively immobile. Increased mobility of linuron may occur under specific environmental conditions (e.g., coarse textured soils; soils with low organic matter levels). Linuron dissipates principally by biotic processes such as microbial degradation. Degradation of linuron by abiotic processes (hydrolysis, photolysis, volatilization) does not appear to be a significant route of dissipation. Partially acceptable and supplemental information on leaching and adsorption/desorption suggests that linuron is primarily adsorbed to soil organic matter with limited adsorption to the inorganic, mineral phase of soil. Linuron would tend to be more mobile in surface soils with low organic matter levels, subsoils or subsoils exposed on the land surface because of erosion. Decreased adsorption in low organic matter soil horizons may result in enhanced mobility and increased leaching potential of parent linuron. For surface soils with adequate organic matter levels, the combined processes of adsorption and microbial degradation would limit the potential for linuron to migrate to ground water. Transport of linuron dissolved in surface runoff and/or in suspended sediment through runoff to surface water bodies (lakes, streams, etc.) could result; however, based on degradation rates and by-products from anaerobic aquatic metabolism studies, fairly rapid degradation of parent linuron to three primary metabolites (desmethoxy linuron, desmethoxy monolinuron, norlinuron) would occur. Information on the mobility and persistence of these primary degradates is not currently available from the studies submitted for the environmental fate data base.

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SECTION 2. SUMMARY OF THE ENVIRONMENTAL FATE ASSESSMENT

Following review of acceptable, limited and supplemental information in the environmental fate data base, linuron appears to be moderately persistent and relatively immobile. Increased mobility of linuron may occur under specific environmental conditions (e.g., coarse textured soils; soils with low organic matter levels). Degradation of parent linuron is primarily microbially-mediated with an aerobic soil half-life ($t_{1/2}$) of 49 days and an anaerobic aquatic $t_{1/2}$ <21 days. Abiotic processes such as hydrolysis ($t_{1/2}$ >30 days for pH 5, 7, 9; calculated average $t_{1/2}$ ≈945 days) and photolysis (aqueous $t_{1/2}$ >30 days; soil $t_{1/2}$ >15 days) are of limited effectiveness in degrading linuron. The relatively low vapor pressure of linuron (1.5×10^{-5} mm Hg at 24° C) suggests that volatility and subsequent photolysis in the atmosphere would not be a significant route of dissipation. Partially acceptable and supplemental information from terrestrial field dissipation studies in California and Delaware reports $t_{1/2}$s ranging from 75 to 100 days for California and a terrestrial field dissipation $t_{1/2}$ of 57 days for Delaware. Linuron does not bioaccumulate in bluegill sunfish with bioconcentration factors (BCFs) ranging from ≈40 for muscle, carcass and whole fish, to a maximum BCF of 240 for sunfish viscera. Elimination of [^{14}C] linuron was ≈92% complete after a 14-day depuration period.

Based on partially acceptable and supplemental information in the data base, linuron is slightly mobile in coarse textured soils (K_{ads} = 2.7-5.0 mL/g) and relatively immobile in fine-textured soils (K_{ads} ≈7.5 mL/g). Interpretation of mobility based on soil texture information alone may not be valid because linuron adsorption appears to be controlled by soil organic matter. Adsorption of linuron was positively correlated with soil organic matter; therefore, surface soil horizons with higher amounts of organic matter typically display greater adsorption of linuron. The adsorption of linuron primarily to soil organic matter may indicate a tendency for linuron to display enhanced mobility if the applied herbicide is transported from the surface horizons immediately following application. Enhanced mobility could result if linuron is applied to surface soils low in organic matter or if heavy rainfall occurs following field application. Furthermore, degradation of linuron is primarily microbially-mediated, thus movement of linuron into less biologically-active subsoils may increase persistence and the possibility of downward translocation (leaching) of linuron under specific environmental conditions. Linuron adsorbed to entrained soil particles or dissolved in surface runoff may also transport the applied herbicide from the targeted field areas to surface water bodies; however, based on the results from the anaerobic aquatic metabolism studies, relatively rapid metabolism to three primary degradates (desmethoxy linuron, desmethoxy monolinuron, norlinuron) is expected. Information on the persistence and mobility of these three degradates is necessary to complete a comprehensive environmental fate assessment.

Information reported in the "Pesticides in Ground Water Database" (Hoheisel et al., 1992) shows detections of linuron in 111 of the 1,666 wells sampled. Linuron concentrations in ground water ranged from 0.042-5.00 μg/L with four states reporting detectable levels. Georgia reported linuron concentrations ranging from 1-5 μg/L for 67 of 70 wells sampled; Missouri showed levels of 0.2-1.9 μg/L for 38 of 269 wells sampled; Virginia listed linuron detections in 5 of 12 wells sampled with concentrations ranging from 0.04-3.8 μg/L; and Wisconsin had 1 detection of 3.0 μg/L in 26 sampled wells.

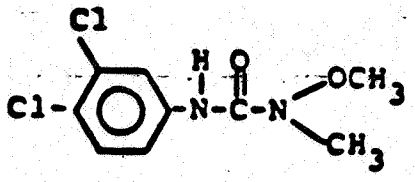
Chemical Information

Common Name: Linuron

Chemical Name: 3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea

Trade Name: Linex 50DF, Lorox Plus, Lorox L, Gemini

Structure:



Physical/Chemical Properties:

Molecular formula: $C_9H_{10}Cl_2N_2O_2$
Molecular weight: 249.1
Physical state: Colorless crystals
Melting point: 93-94° C
Vapor pressure: 1.5×10^{-5} mm Hg at 24° C
Solubility: 81 mg/L in water at 24° C

Use Patterns

The following information on use patterns was obtained from labeling material and the LUIS Report dated 5/15/92. Linuron (3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea) is a broad spectrum herbicide for control of many annual grasses and broadleaf weeds in terrestrial food, terrestrial non-food and forestry use areas. Linuron, a substituted urea herbicide, controls numerous weeds reportedly through inhibition of photosynthesis. Linuron is used as a pre- and post-emergent selective herbicide to control various broadleaf weeds and annual grasses such as annual ryegrass, buttonweed, canarygrass, chickweed, crabgrass, dog fennel, fall panicum, foxtail grasses, goosegrass, lambsquarters, morning glory, mustard, nettleleaf, pigweed, purslane, ragweed, smartweed, velvetleaf, wild buckwheat, wild radish and others in field corn, sweet corn (layby), grain sorghum, soybeans, asparagus, carrots, celery (post transplant), parsnips, potatoes, cotton (layby), and wheat (Pacific Northwest). Linuron has been proposed for use on parsley and is also for short-term control of annual weeds in terrestrial nonfood areas such as roadsides and fence rows. Additional application areas include ornamental herbaceous plants such as Dutch iris, daffodil, calla lily and tulip bulbs and weed control for hybrid poplar trees.

Field application of linuron is performed with ground spray equipment such as a tractor-mounted, fixed-boom sprayer. Aerial applications are prohibited. Single active ingredient formulations are emulsifiable and flowable concentrates, wettable powder, flowable liquid, and water dispersible granular (dry flowable). Multiple active ingredient formulations

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include other herbicides such as atrazine, chloramben, metribuzin, metolachlor, oryzalin, paraquat, propachlor, propazine, and trietazine. Linuron may be tank mixed with 2,4-D and lenacil. Typical use rates range from 0.5-3.0 lb ai/A, depending on crop and soil type. According to label directions, maximum application rates of 4 lb ai/A are recommended for fine-textured soils such as clays and silty clays.

Status of Data Requirements

The environmental fate assessment was based on the following acceptable studies:

- 161-1: Hydrolysis (MRID# 40916201);
- 161-2: Photodegradation in Water (MRID# 40103601);
- 161-3: Photodegradation on Soil (MRID# 40171711);
- 162-1: Aerobic Soil Metabolism (MRID# 41625401);
- 162-3: Anaerobic Aquatic Metabolism (MRID# 40142501);
- 164-4: Bioaccumulation in Fish (Accession No. 258300).

The environmental fate assessment was based on the following partially acceptable studies:

- 163-1: Leaching/Adsorption/Desorption (MRID# 00148443; Acc. No. 257620);
- 163-1: Leaching/Adsorption/Desorption (Accession No. 255830);
- 164-1: Terrestrial Field Dissipation (MRID# 41734201).

The environmental fate assessment was based on the following supplemental studies:

- 163-1: Leaching/Adsorption/Desorption (MRID# 05016640);
- 163-1: Leaching/Adsorption/Desorption (MRID# 05019711);
- 163-1: Leaching/Adsorption/Desorption (MRID# 05019500);
- 164-1: Terrestrial Field Dissipation (MRID# 41734202).

SECTION 3. TECHNICAL SUMMARIES OF THE ENVIRONMENTAL FATE STUDIES

The following data summary is derived from studies considered acceptable by EFGWB:

161-1: Hydrolysis

Stevenson, I.E. 1988. Hydrolysis of [phenyl-^{14}C(U)]linuron in water buffered at pH 5, pH 7, and pH 9. MRID# 40916201

Phenyl-labeled [^{14}C] linuron (radiochemical purity 97%), at ≈30 ppm, did not hydrolytically degrade in sterile aqueous 0.005-0.010 M buffer solutions adjusted to pH 5, 7, or 9 and incubated in the dark at 25 ± 1° C for 30 days. At 30 days posttreatment, 96.0-98.4% of the applied [^{14}C] linuron remained undegraded; the registrant calculated half-lives for linuron in the buffer solutions averaged 945 days. Minor degradates, each found at ≈1% of the applied, were 3,4-dichlorobenzenamine (DCA), N-(3,4-dichlorophenyl)-N'-methylurea (DCPMU), N-(3,4-dichlorophenyl)-N'-methoxyurea (DML), and (3,4-

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dichlorophenyl)urea (DCPU). During the 30-day study, measured volatiles were $\leq$ 0.04% of the applied radioactivity. Material balances ranged from 94.4 to 107% of the applied radioactivity.

161-2: Photodegradation in Water

Buchta, R.C. 1986. Photodegradation of [phenyl-^{14}C(U)]linuron in water. MRID# 40103601

Phenyl-labeled [^{14}C] linuron (radiochemical purity 99%), at 18 ppm, degraded with a half-life of >30 days (registrant-calculated half-life of 49 days) in a sterile aqueous pH 5 buffered solution irradiated with natural sunlight (May in Wilmington, DE) at 25° C. At 30 days posttreatment (total light intensity = 196,006 Watt-hours/m^2), linuron comprised 61.6% of the applied radioactivity; volatiles totaled 10.2% of the applied and unidentified degradates (at least 8 separate peaks) each accounted for up to 5.1% of the applied. In the dark control after 30 days, 92.1% of the recovered was undegraded parent linuron, suggesting the observed degradation was primarily photolytic rather than hydrolytic. The ultraviolet-visible light absorption spectrum for linuron at 18 ppm displayed absorption maxima at 210, 245, and 280 nm with some overlap at >290 nm, further supporting direct photolysis of the parent linuron.

161-3: Photodegradation on Soil

Brown, A.M. 1986. Photodegradation of [phenyl-^{14}C(U)]linuron on soil. MRID# 40171711

Phenyl-labeled [^{14}C] linuron (radiochemical purity >98%), at 7.5 lb ai/A (1.63 mg/plate), degraded with a half-life >15 days on silt loam soil irradiated continuously with a Pyrex glass-filtered xenon arc light at 25° C. After 15 days of irradiation, the soil contained 78.8% of the recovered radioactivity as parent linuron. Minor degradates identified were norlinuron, desmethyl linuron, and 3,4-dichloroaniline (each <8.4% of the recovered). Unidentified polar compounds comprised <4% of the recovered, unextractable compounds were <2.5% of the recovered, and volatiles were <0.1% of the recovered at all sampling intervals. In the dark controls, parent linuron accounted for 96.5% of the recovered radioactivity after 15 days, suggesting that degradation was primarily photolytic and not biologically-mediated. Material balance for all samples ranged from 95 to 123% of the applied and averaged 110% of the applied.

162-1: Aerobic Soil Metabolism

Schneiders, G.E. 1990. Aerobic soil metabolism of [phenyl-^{14}C(U)]linuron in Hanford sandy loam. MRID# 41625401

Linuron degraded with a half-life of 49 days in sandy loam soil that was incubated in the dark at 25° C and 75% of 0.33 bar moisture content. The primary nonvolatile degradate was 3-(3,4-dichlorophenyl)-1-methylurea (desmethoxy linuron; maximum average concentration of 3.0% of the applied at 120 days posttreatment, decreasing to 1.9% of the applied by 365 days); other nonvolatile degradates were 3-(3,4-dichlorophenyl)-1-methoxyurea (desmethyl linuron; maximum average concentration of 2.1% of the applied at 365 days posttreatment)

and 1-(3,4-dichlorophenyl)urea (norlinuron; maximum average concentration of 1.9% of the applied at 28 days). By 12 months posttreatment, unidentified polar [^{14}C]residues increased to 4.7% (0.20 ppm) of the applied and "other" unidentified [^{14}C]residues comprised 1.8% (0.07 ppm). At 12 months posttreatment, $^{14}CO_2$ was the major degradate (totaled 69% of the applied).

162-3: Anaerobic Aquatic Metabolism

Monson, K.D. 1986. Anaerobic aquatic metabolism of [phenyl-^{14}C(U)] linuron. MRID# 40142501

Phenyl-labeled [^{14}C] linuron (radiochemical purity 88%), at 5 ppm, degraded with a half-life of <3 weeks in nonsterile anaerobic (flooding plus N_2 atmosphere) silt loam or sand soil:water (1:1) system incubated in the dark at 24° C. [^{14}C] Linuron was not detected (detection limit not specified) in either system by 26 weeks posttreatment. In the silt loam soil system at three weeks posttreatment (first sampling interval following treatment), 10.8% of the applied radioactivity remained as parent linuron (registrant-calculated half-life of 1 week). The two major degradates were desmethoxy linuron (maximum of 46.7% of the applied at 3 weeks posttreatment) and desmethoxy monolinuron (maximum of 78% of the applied at 26 weeks). Minor degradates, each <5.7% of the applied, were desmethyl linuron, norlinuron, and dichloroaniline. Unidentified (polar compounds; unidentified compounds; background radioactivity) and unextractable [^{14}C] residues accounted for up to 21.8 and 27% of the applied, respectively. In the sand soil system, the major degradates were desmethoxy linuron (maximum of 84.6% of the applied at 26 weeks) and norlinuron (maximum of 33% of the applied at 52 weeks). Minor degradates, each found at <5% of the applied, were desmethyl linuron, dichloroaniline, and desmethoxy monolinuron. Unidentified and unextractable [^{14}C] residues comprised up to 28.4 and 16.4% of the applied, respectively. Except for the samples taken immediately posttreatment, the majority of the radioactivity in both soil:water systems was associated with the soil fraction.

In anaerobic sterile silt loam and sand soil systems, phenyl-labeled [^{14}C] degraded with half-lives of <4 weeks (registrant-calculated half-life of 3.5 weeks) and >52 weeks, respectively. In the sterile silt loam system, only 14.6% of the applied remained as undegraded parent linuron at 4 weeks posttreatment, whereas, in the sterile sand soil system, 62.4% of the applied remained as undegraded linuron at 52 weeks posttreatment. The registrant stated that the sterile silt loam system may not have been anaerobic (reported redox potential of 216 millivolts; pH unspecified); therefore, more rapid degradation was observed in the silt loam system relative to the sand soil system. Furthermore, the sterility of the silt loam system was not confirmed and microbial metabolic processes may have increased the degradation rate.

164-4: Bioaccumulation in Fish

Butler, L.D. 1985. Laboratory studies of phenyl-^{14}C linuron bioconcentration in bluegill sunfish. Accession #258300

[^{14}C] Linuron (>99% pure) at 0.1 and 1.0 ppm, accumulated in bluegill sunfish, with maximum bioconcentration factors of 34x, 39x, 49x, and 240x, in muscle, carcass, whole

fish, and viscera, respectively. After 28 days of exposure, [^{14}C] linuron residues consisted c 'esmethyl linuron (≈18-24%), linuron (15-22%), norlinuron (7-10%), and glucuronide residues (8-12%). No analyses of [^{14}C] linuron residues were completed on the muscle tissue. Elimination of [^{14}C] linuron residues was >66% after a 1-day depuration period and 92% complete after a 14-day depuration period.

The following data summary is derived from studies considered partially acceptable by EFGWB:

163-1: Leaching/Adsorption/Desorption

Priester, T.M. 1985. Batch equilibrium (adsorption/desorption) and soil thin-layer chromatography studies with [phenyl-^{14}C(U)] linuron. MRID# 00148443; Accession No. 257620

Priester, T.M. 1988. Supplement #1: Batch equilibrium (adsorption/desorption) and soil thin-layer chromatography studies with [phenyl-^{14}C(U)] linuron. MRID# 40559001

Priester, T.M. 1992. Supplement #2: Batch equilibrium (adsorption/desorption) and soil thin-layer chromatography studies with [phenyl-^{14}C(U)] linuron. MRID# 42264601

Soil adsorption/desorption of uniformly-labeled [^{14}C] linuron (purity >99%) was studied using batch equilibrium tests of 4 soils. Measured K_{ads} suggest that linuron is slightly mobile in coarse textured soils (Woodstown sandy loam [DE]; fine-loamy, mixed, mesic Aquic Hapludults; 60% sand, 33% silt, 7% clay; pH = 6.6; Cecil sandy loam [NC]; clayey, kaolinitic, thermic Typic Kanhapludults; 61% sand, 21% silt, 18% clay; pH = 6.5) and relatively immobile in fine textured soils (Flanagan silt loam [IL]; fine, montmorillonitic, mesic, Aquic Argiudolls; 2% sand, 81% silt, 17 % clay; pH = 5.4; Keyport silt loam [DE]; clayey, mixed, mesic Aquic Hapludults; 12% sand, 83% silt, 5% clay; pH = 5.2). Interpretation of mobility based on soil texture information alone may not be valid because linuron adsorption appears to be controlled by soil organic matter. Adsorption of linuron was positively correlated with soil organic matter content.

Soil Type	Clay (%)	Organic Matter (%)	CEC (meq/100g)	K_{ads} (mL/g)	K_{des} (mL/g)	$K_{ads,oc}$ (mL/g)	$K_{des,oc}$ (mL/g)
Woodstown sl[1]	7	1.1	5.3	2.7	3.6	241	327
Cecil sl	18	2.1	6.6	5.0	4.5	238	214
Flanagan sil[2]	17	4.3	21.1	7.7	4.7	179	109
Keyport sil	5	7.5	15.5	7.2	4.8	96	65

Notes: [1]sl = sandy loam; [2]sil = silt loam

163-1: Leaching/Adsorption/Desorption

Chrzanowski, R.L. 1984. Soil column adsorption studies with Lorox linuron weed killer. Accession No. 255830

Based on the results of soil column leaching studies, linuron (unaged and "aged" 30 days) was sligh' y mobile to relatively immobile in Fallsington sandy loam (Glasgow, DE; 59%

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sand, 30% silt, 10% clay; 0.79% organic matter (OM); pH = 6.6; CEC = 5.2 meq/100g) and Flanagan silty clay loam (Rochelle, IL; 5% sand, 64% silt, 31% clay; 4.0% OM; pH = 7.0; CEC = 23.4 meq/100g) soil columns, respectively. For the unaged tests, after leaching 18-in. repacked soil columns (2-in. diameter) with 20 in. of water, 0.4% of the applied radioactivity was present in the leachate for both soils. For the "aged" tests under similar experimental conditions, 0.3 and 0.2% of the applied was measured in the leachate. For the unaged and "aged" tests on the Fallsington sandy loam, maximum linuron concentrations were found at the 6-8 in. depth (≈25% of the applied) and 8-10 in. depth (≈23% of the applied), respectively. The unaged and "aged" tests on the Flanagan silty clay loam exhibited maximum linuron concentrations at the 0-2 in. depth (≈83 and 75% of the applied, respectively).

Additional data required for the leaching/adsorption/desorption studies will be used to help determine the mobility of linuron's significant degradates under typical use conditions. The mobility data (partitioning coefficients, K_ds) may be applied to complete computer simulation models assessing the fate and transport of the primary degradates.

164-1: Terrestrial Field Dissipation

Eble, J.E. 1990. Field soil dissipation of linuron herbicide. MRID# 41734201

Linuron dissipated with a calculated half-life of 100 days from the upper 15 cm of a plot of sandy loam soil in California after an application of linuron (Lorox DF, 50% dry flowable) at 6 lb ai/A, and with a half-life of 57 days from the upper 15 cm of a plot of silty clay loam soil in Delaware after an application of linuron (Lorox L, 4 lb ai/gallon flowable concentrate) at 1 lb ai/A. Total linuron residues (linuron plus its degradates desmethoxy-linuron, desmethyl-linuron, norlinuron, and 3,4-dichloroaniline hydrolyzed to 3,4-dichloroaniline) dissipated from the 0- to 15-cm soil depth with an observed half-life of approximately 9-12 months at both sites. Parent linuron was detected at low levels (≈0.02 ppm) for one month posttreatment at both sites in soil samples collected from the 15-30 cm depth. Total linuron residues were detected in the 15- to 30-cm soil layer at both sites (<0.01-0.05 ppm); soil layers below 30 cm were not analyzed for total linuron residues. For sampling depths deeper than 30 cm, the 15-cm soil segments "for selected sampling intervals" were either analyzed as 30-45 cm samples or composited into 30- to 90-cm samples; parent linuron was not reported at concentrations above the detection limit (<0.01 ppm).

Studies of terrestrial field dissipation provide data to evaluate patterns of pesticide residue dissipation in field environments. Additional information is required for the terrestrial field dissipation studies because the patterns of formation and decline of total linuron residues could not be assessed; and field test procedures and analytical methodology were not completely described.

164-1: Freezer Storage Stability In Soil

Tomic, D.M. 1992. Freezer storage stability of linuron in soil. MRID# 42422801

Linuron ppeared to be stable in silty clay loam soil that was treated with linuron [3-(3,4-

dichlorophenyl)-1-methoxy-1-methylurea; purity 98.8%] at 1 ppm and stored frozen (-20° C for up to 30 months. At 30 months posttreatment, parent linuron comprised 86-90% of the applied (percent recovery normalized to recovery from fresh fortifications). During the study, recovery of linuron from stored soil samples ranged from 82 to 115% of the applied (normalized). If samples are stored frozen for longer than 30 months prior to analysis, storage stability information for longer periods will be required. In addition, storage stability data are needed for individual degradates of linuron.

Actual recoveries of applied linuron from stored fortified soil decreased in the 24-, 26-, and 30-month samples; however, the decreased recoveries from stored soil samples coincided with poor recoveries from freshly fortified samples. Parent linuron comprised 76-114% of the applied in the soil samples stored for 0 to 18 months, then decreased to 56-66% of applied in the samples stored for 24 and 30 months. Similarly, linuron comprised 78-112% of the applied in freshly fortified soil samples extracted concurrently with the 0- to 18-month stored soil and decreased to 60-73% of applied in freshly fortified samples extracted concurrently with the 24- to 30-month stored samples.

The following data summary is derived from studies considered supplemental by EFGWB:

163-1: Leaching/Adsorption/Desorption

Abernathy, J.R. 1972. Linuron, chlorbromuron, nitrofen, and fluorodifen adsorption and movement in twelve selected Illinois soils. MRID# 05019500

Grover, R. 1975. Adsorption and desorption of urea herbicides on soils. MRID# 05016640

Hance, R.J. 1971. Complex formation as an adsorption mechanism for linuron and atrazine. MRID# 05019711

Several early investigations of the adsorption of linuron provide supplemental information which indicates sorption is probably related to the organic matter content of soils. In a study of the adsorption and desorption of urea herbicides, Grover (1975) reported adsorption of linuron was significantly correlated with soil organic matter but not clay content. Desorption of linuron was limited in a high organic matter (10.5%) loam soil when compared to four other soils ranging from 6.5-1.8% organic matter and 8-70% clay. Hance (1971) postulated that the formation of complexes with exchangeable cations could play a significant role in linuron adsorption in soil. Abernathy (1972) showed adsorption of [^{14}C] linuron for 12 selected Illinois soils was highly correlated to organic matter with no correlations between adsorption of linuron and temperature, pH, clay, silt, or sand.

164-1: Terrestrial Field Dissipation

Eble, J.E. 1990. Field soil dissipation of linuron herbicide in California soil. MRID# 41734202

Linuron dissipated with a registrant-calculated half-life of 75 days from the upper 15 cm of a plot (15 x 80 feet) of sandy clay loam soil planted to soybeans in California following a preemergence application of linuron [3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea; Lorox DF, 50% dry flowable] at 6 lb ai/A in June 1989. In the 0- to 15-cm soil depth, linuron

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decreased from an average of 1.14-2.07 ppm at 0-1 days posttreatment (maximum 3.31 ppm at 1 day) to 0.58 ppm at 7 days, increased to 1.21 ppm at 14 days, then decreased to 1.05 ppm at 29 days, 0.56 ppm at 90 days, 0.18 ppm at 181 days, and 0.05 ppm at 365 days (Table II). Linuron may have leached into lower soil depths (15- to 30- and 30- to 90-cm depths); however, analysis of the pattern of leaching appeared to have been confounded by contamination of several of the subsurface soil samples during sampling. In the 15- to 30-cm depth, linuron was detected at an average of 0.02-0.03 ppm at 0-1 days posttreatment, 0.01 ppm at 7 days, 0.04 ppm (maximum 0.07 ppm) at 14 days, <0.01-0.03 ppm at 29-119 days, and <0.01 ppm (limit of quantitation) at 181, 270, and 365 days. In the 30- to 45-cm soil depth, linuron was detected at an average of 0.12 ppm (maximum 0.22 ppm) at 0 day posttreatment. In the 30- to 90-cm soil depth, linuron increased from an average of 0.02 ppm at 1-7 days posttreatment to 0.09 ppm (maximum 0.14 ppm) at 14 days, and was ≤0.01 ppm at 29-365 days.

SECTION 4. ASSESSMENT OF LINURON DETECTIONS IN GROUND WATER

To date, linuron has been detected in ground water in four states -- Georgia, Missouri, Virginia, and Wisconsin (Hoheisel et al., 1992). Review of the studies in which the ground water detections were reported gave the following results:

1. Georgia

   Detections in ground water were solely from STORET which did not allow a detailed review. Concentrations of linuron ranged from 1 to 5 μg/L (ppb).

2. Missouri

   Rural private wells in agricultural areas of Missouri were monitored for pesticide residues. Linuron was detected at concentrations ranging from 0.5 to 1.9 μg/L (Sievers and Fulhage, 1989a and 1991). In another study conducted in Missouri (Sievers and Fulhage, 1989b), linuron was also detected in ground water in rural agricultural wells at levels ranging from 0.48 to 0.9 μg/L. The study examined ground-water quality in eight major agricultural areas in the state, without regard to the vulnerability of the soils to leaching, nor to areas of high linuron use.

   Dennis Sievers (personal communication, 1994) related to the GWTS that there were some interference problems with the mass spectrometer detector due to sulfur and organic matter. Mr. Sievers was very confident regarding the linuron detections above 1 μg/L, but less confident with the detections reported below 1 μg/L. No information was provided about the wells, depth to ground water, or detection limits.

3. Virginia

   Eight monitoring wells and four household wells were sampled for a suite of pesticides including linuron (Mostaghimi, 1992). There were no indications of

point-source contamination or problems with the wells during the study. Linuron was detected in 50% of the monitoring wells (4 of 8 wells) at levels ranging from 0.35 to 1.31 μg/L. The extensive QA/QC plan for the sampling program and GC analysis provided a high degree of confidence for these detections.

4. Wisconsin

In a Wisconsin study (Postle and Brey, 1991), monitoring wells were located in areas that were highly vulnerable to ground-water contamination. All detections were from areas with normal field use conditions. Linuron was detected at one site at concentrations that ranged from 1.3 to 2.7 μg/L.

Using a Reference Dose (RfD) of 0.002 mg/kg/day in a dog feeding study, the lifetime Health Advisory for linuron in drinking water was estimated to be 1.4 μg/L. Linuron has been placed in Cancer Group C (unquantified) indicating that it is a possible human carcinogen. Linuron has been detected in ground water in four states including Georgia, Missouri, Virginia, and Wisconsin at levels ranging up to 5.00 μg/L (Hoheisel et al., 1992).

Linuron exhibits some of the properties and characteristics associated with chemicals that have been detected in ground water. Linuron is a persistent chemical with an aerobic soil metabolism half-life that ranges from 84 to 91 days (12 to 13 weeks). In addition, its field dissipation half-life has been reported to range from a minimum of 57 days to a maximum of 100 days ($\approx$8 to $\approx$14 weeks, respectively). Based on its persistence, linuron use may have a significant impact on ground-water quality.

Because linuron is persistent and may be mobile under certain environmental conditions, it has the potential to significantly impact ground-water quality at levels that may affect human health. To date, linuron residues have been detected in ground water in three states above estimated lifetime Health Advisory levels. Potential concentrations of linuron in ground water are not likely to exceed the other risk-based Levels of Concern for ecological effects (see Figure 1).

Linuron Detections in Ground Water Exceed the Following Levels of Concern:

♦ **GROUND-WATER QUALITY.** Linuron has been detected in ground water in Georgia, Missouri, Virginia, and Wisconsin with detectable levels above the estimated toxicity threshold for humans. Considering the widespread use of linuron and its environmental fate characteristics, EFGWB is concerned about the degradation of water quality that might occur in linuron use areas.

♦ **HUMAN HEALTH.** Linuron residues have been detected in ground water at levels which exceed the estimated lifetime Health Advisory. To date, no information is available about the degradates in ground water, but additional information on the persistence and mobility of the degradates has been requested in this document. If the toxicity of the three degradates is similar to the parent, the combined concentrations

of parent linuron and its degradates in ground water may greatly exceed the levels of concern for human health.

SECTION 5. RECOMMENDATIONS

Because linuron exceeds certain Levels of Concern for ground water, EFGWB recommends the following:

1. Linuron has been detected in ground water. Therefore, all product labels should carry the following advisory:

   "This chemical is known to leach through soil into ground water under certain conditions as a result of agricultural use. Use of this chemical in areas where soils are permeable, particularly where the water table is shallow, may result in ground-water contamination."

2. EFGWB recommends that prospective ground-water monitoring studies be conducted for linuron. In order to determine the potential of this chemical to leach to ground water, an adequate number of studies should be conducted to characterize linuron use. Study areas should include those with coarse-textured soils low in organic matter, and those more representative of typical linuron use areas.

3. Linuron meets the persistence and mobility triggers for classification as a restricted use chemical for ground-water concerns. EFGWB recommends that linuron be considered for classification as a restricted use chemical based on ground-water concerns.

4. Linuron has been detected in ground water as a result of normal agricultural use at levels that exceed its estimated lifetime Health Advisory. The registrant should determine the areas that are vulnerable to ground-water contamination by linuron, and recommend label restrictions.

5. The registrant and EPA will agree, as a condition of reregistration eligibility, to establish criteria for additional mitigation, suspension, and voluntary cancellation as a consequence of monitoring study results.

Environmental Fate Data Requirements

The current status of the environmental fate data requirements for the terrestrial food, terrestrial non-food, and forestry use patterns is briefly summarized below and outlined in detail in the attached Table A.

Data Requirement	Status	MRID No.
161-1: Hydrolysis	Fulfilled	40916201
161-2: Photolysis in Water	Fulfilled	40103601
161-3: Photolysis on Soil	Fulfilled	40171701

161-4: Photolysis in Air	Waived[1]	----
162-1: Aerobic Soil Metabolism	Fulfilled	00125244 41625401
162-2: Anaerobic Soil Metabolism	Fulfilled	40142501
162-3: Anaerobic Aquatic Metabolism	Fulfilled	40142501
163-1: Leaching/Sorption	Not fulfilled[2]	00148443 Acc.#255830
163-2: Volatility (Laboratory)	Waived[1]	----
163-3: Volatility (Field)	Waived[1]	----
164-1: Terrestrial Field Dissipation	Not fulfilled[3]	41734201 41734202 42422801
165-1: Confined Rotational Crop	Fulfilled	40730101
165-2: Field Rotational Crop	Waived[4]	----
165-4: Bioaccumulation in Fish	Fulfilled	Acc.# 258300
166-1: Ground Water - Prospective	Not Fulfilled[5]	----

Notes:

[1] The Photodegradation in Air (161-4), Volatility (Laboratory; 163-2) and Volatility (Field; 163-3) data requirements were waived because the reported vapor pressure of linuron is 1.5×10^{-5} mm Hg at 24° C.

[2] The Leaching/Adsorption/Desorption (163-1) data requirement is not fulfilled because information on the K_ds for the major linuron degradates under anaerobic conditions (desmethoxy linuron, desmethoxy monolinuron, norlinuron) is not currently available. Adsorption coefficients (K_ds) may be determined using batch equilibrium test methodology.

[3] The Terrestrial Field Dissipation (164-1) data requirement is not fulfilled because the patterns of formation and decline of total linuron residues could not be assessed; and field test procedures and analytical methodology were not completely described. The California study may be upgradeable if additional information on study methods and early soil sample results can be provided; however, the Delaware study can not be upgraded because the consistent presence of linuron in the control plot confounds accurate assessment of the pattern of formation and decline of total linuron residues. A new study is needed to satisfy the data requirement.

[4] Information on the 165-2 data requirement waiver may be obtained from RCB/HED (Review Date 3/23/90).

[5] In order to determine the potential of this chemical to leach to ground water, an adequate number of studies should be conducted to characterize linuron use. Study areas should include those with coarse-textured soils low in organic matter, and those more representative of typical linuron use areas.

The following data requirements are fulfilled:

161-1: Hydrolysis - The study by Stevenson (1988; MRID# 40916201) was reviewed and found acceptable for fulfilling the Hydrolysis data requirement. Phenyl-labeled [^{14}C] linuron did not degrade via hydrolysis in sterile buffer solutions at pH 5, 7, or 9 and incubated in the dark at 25 ± 1 °C for 30 days.

161-2: Photodegradation in Water - A study by Buchta (1986; MRID# 40103601) was reviewed and found acceptable for fulfilling the Photodegradation in Water data requirement. Phenyl-labeled [^{14}C] linuron degraded slowly with a half-life of >30 days (registrant-calculated half-life of 49 days) in sterile aqueous pH 5 buffer solution irradiated with natural sunlight (May in Wilmington, DE) at 25° C.

161-3: Photodegradation on Soil - The study by Brown (1986; MRID# 40171711) was reviewed and found acceptable for fulfilling the Photodegradation on Soil data requirement.

Phenyl-labeled [^{14}C] linuron degraded very slowly with a half-life >15 days on silt loam soil irradiated continuously with a Pyrex glass-filtered xenon arc light at 25° C.

162-1: Aerobic Soil Metabolism - The study by Schneiders (1990; MRID# 41625401) was reviewed and found acceptable for fulfilling the Aerobic Soil Metabolism data requirement. Linuron degraded with a half-life of 49 days in sandy loam soil that was incubated in the dark at 25° C and 75% of 0.33 bar moisture content. Several degradates were reported in small concentrations (desmethoxy linuron, ≈3%; desmethyl linuron, ≈2%; norlinuron, ≈2%). At 12 months posttreatment, CO_2 was the major degradate (≈70% of the applied).

162-2: Anaerobic Soil Metabolism - No studies were reviewed. The Anaerobic Aquatic Metabolism study was used to fulfill this data requirement.

162-3: Anaerobic Aquatic Metabolism - The study by Monson (1986; MRID# 40142501) was reviewed and found acceptable for fulfilling the Anaerobic Soil Metabolism data requirement. Phenyl-labeled [^{14}C] linuron degraded with a half-life of <3 weeks in nonsterile anaerobic silt loam and sand soil: water (1:1) systems incubated in the dark at 24° C. Primary degradates were desmethoxy linuron (range of ≈50-85% of the applied), desmethoxy monolinuron (≈78% of the applied in the silt loam), and norlinuron (≈33% of the applied in the sand soil). Minor (<5% of the applied) degradates were desmethyl linuron and dichloroaniline.

165-4: Bioaccumulation in Fish - The study by Butler (1985, Accession #258300) was reviewed and found acceptable for fulfilling the Bioaccumulation in Fish data requirement. Linuron residues accumulated in bluegill sunfish during 28 days of exposure to water treated at 0.1 and 1.0 ppm [^{14}C] linuron. Maximum bioconcentration factors were 49x for whole fish, 240x for viscera, 34x for muscle and 39x for carcass tissues. After 28 days of exposure, linuron residues in the viscera were identified as desmethyl linuron, norlinuron, and glucuronide conjugates. The edible tissues were not analyzed for linuron residues. Residues rapidly declined to ≈10% of maximum levels after the 14-day depuration period.

The following data requirements are not fulfilled:

163-1: Leaching/Adsorption/Desorption - Two studies were reviewed (Preister, 1985; MRID# 00148443; Chrzanowski, 1984; Accession No. 255830) and provided partially acceptable information on the mobility of linuron. Based on the results of the two studies and supplemental information from three peer-reviewed journal publications on linuron mobility, linuron appears to be slightly mobile in coarse-textured soils (K_{ads} = 2.7-5.0 for sandy loams) and relatively immobile in fine-textured soils (K_{ads} = 7.2-7.7 for silt loams). Adsorption of linuron is probably related to the organic matter content with increased adsorption reported for soils with higher organic matter content ($K_{ads,om}$ <200 for two soils with >4% OM). The Leaching/Adsorption/Desorption (163-1) studies are partially acceptable because information on the K_ds for the primary linuron degradates formed under anaerobic conditions (desmethoxy linuron, desmethoxy monolinuron, norlinuron) is not currently available. Adsorption coefficients (K_ds) may be determined using batch equilibrium test methodology.

164-1: Terrestrial Field Dissipation - Two studies were reviewed (Eble, 1990a, 1990b; MRID# 41734201, 41734202) and provided partially acceptable or supplemental information on the field dissipation of linuron in California and Delaware. The Terrestrial Field Dissipation (164-1) data requirement is not fulfilled because the patterns of formation and decline of total linuron residues could not be assessed; and field test procedures and analytical methodology were not completely described. The California study may be upgradeable if additional information on study methods and early soil sample results can be provided; however, the Delaware study can not be upgraded because the consistent presence of linuron in the control plot confounds accurate assessment of the pattern of formation and decline of total linuron residues. A new study is needed to satisfy the data requirement.

166-1: Ground Water - Prospective - EFGWB recommends that prospective ground-water monitoring studies be conducted for linuron. In order to determine the potential of this chemical to leach to ground water, an adequate number of studies should be conducted to characterize linuron use. Study areas should include those with coarse-textured soils low in organic matter, and those more representative of typical linuron use areas.

The following data requirements are deferred or are not required for presently registered uses:

161-4: Photodegradation in Air - No studies were reviewed. The Photodegradation in Air data requirement was waived because the vapor pressure for linuron was reportedly 1.5×10^{-5} mm Hg at 24° C (2.0 mPa); therefore, volatilization and subsequent photodegradation in air are not considered probable routes of dissipation.

163-2: Volatility - Laboratory - No studies were reviewed. The Laboratory Volatility data requirement was waived because the vapor pressure for linuron was reportedly 1.5×10^{-5} mm Hg at 24° C (2.0 mPa); therefore, volatilization is not considered a probable route of dissipation.

163-3: Volatility - Field - No studies were reviewed. The Field Volatility data requirement was waived because the vapor pressure for linuron was reportedly 1.5×10^{-5} mm Hg at 24° C (2.0 mPa); therefore, volatilization is not considered a probable route of dissipation.

165-1: Confined Rotational Crop - No studies were reviewed. The Confined Rotational Crop data requirement was transferred to RCB/HED (effective 2/22/93). Inquiries regarding this data requirements should be directed to RCB/HED.

165-2: Field Rotational Crop - No studies were reviewed. The Field Rotational Crop data requirement was transferred to RCB/HED (effective 2/22/93). Inquiries regarding this data requirements should be directed to RCB/HED.

201-1: Droplet Size Spectrum - No studies were reviewed. The registrant, Du Pont, is a participating member of the Spray Drift Task Force. Information regarding spray drift of linuron should be provided upon completion of the Spray Drift Task Force data base. This study may be required by EFGWB when toxicological considerations are indicated by either the Ecological Effects Branch and/or the Health Effects Division.

202-1: Drift Field Evaluation - No studies were reviewed. The registrant, Du Pont, is a participating member of the Spray Drift Task Force. Information regarding spray drift of linuron should be provided upon completion of the Spray Drift Task Force data base. This study may be required by EFGWB when toxicological considerations are indicated by either the Ecological Effects Branch and/or the Health Effects Division.

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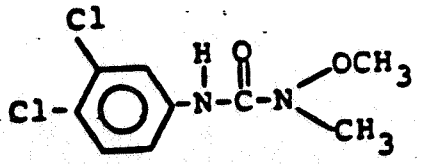
Tomic, D.M. 1992. Freezer storage stability of linuron in soil. MVTL Project ID 02-8906. Du Pont Project ID AMR-1677-90. Unpublished study performed by Minnesota Valley Testing Laboratories, Inc., New Ulm, MN, and submitted by E.I. du Pont de Nemours and Company, Inc., Wilmington, DE. (MRID# 42422801)

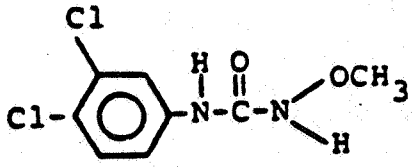
Wisconsin Dept. of Agriculture, Trade, and Consumer Services. 1989. Grade A Dairy Farm Well Water Quality Survey, Wisconsin Agricultural Statistics Service.

APPENDIX: PARENT AND ITS DEGRADATES

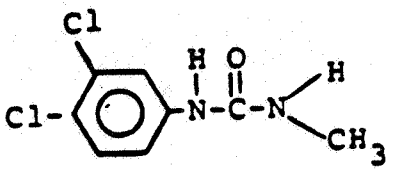
Linuron
(3-(3,4-dichlorophenyl)-1
methoxy-1-methylurea)



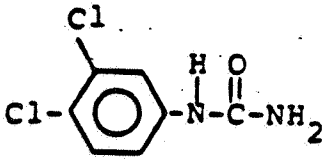
Desmethyl linuron
(3-(3,4-dichlorophenyl)-1-
methoxyurea



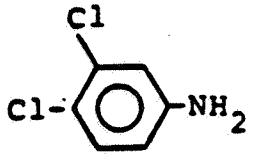
Desmethoxy linuron
(3-(3,4-dichlorophenyl)-1-
methylurea



Norlinuron
(1-(3,4-dichlorophenyl)urea)



DCA
(3,4-dichloroaniline)



TCAB
(3,3',4,4'-tetrachloro-
azobenzene)

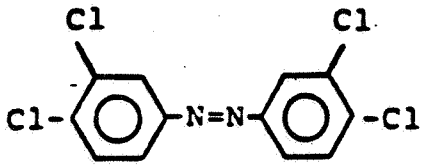


Figure 1. Structure and nomenclature of linuron and its degradation products.

FIGURE 1

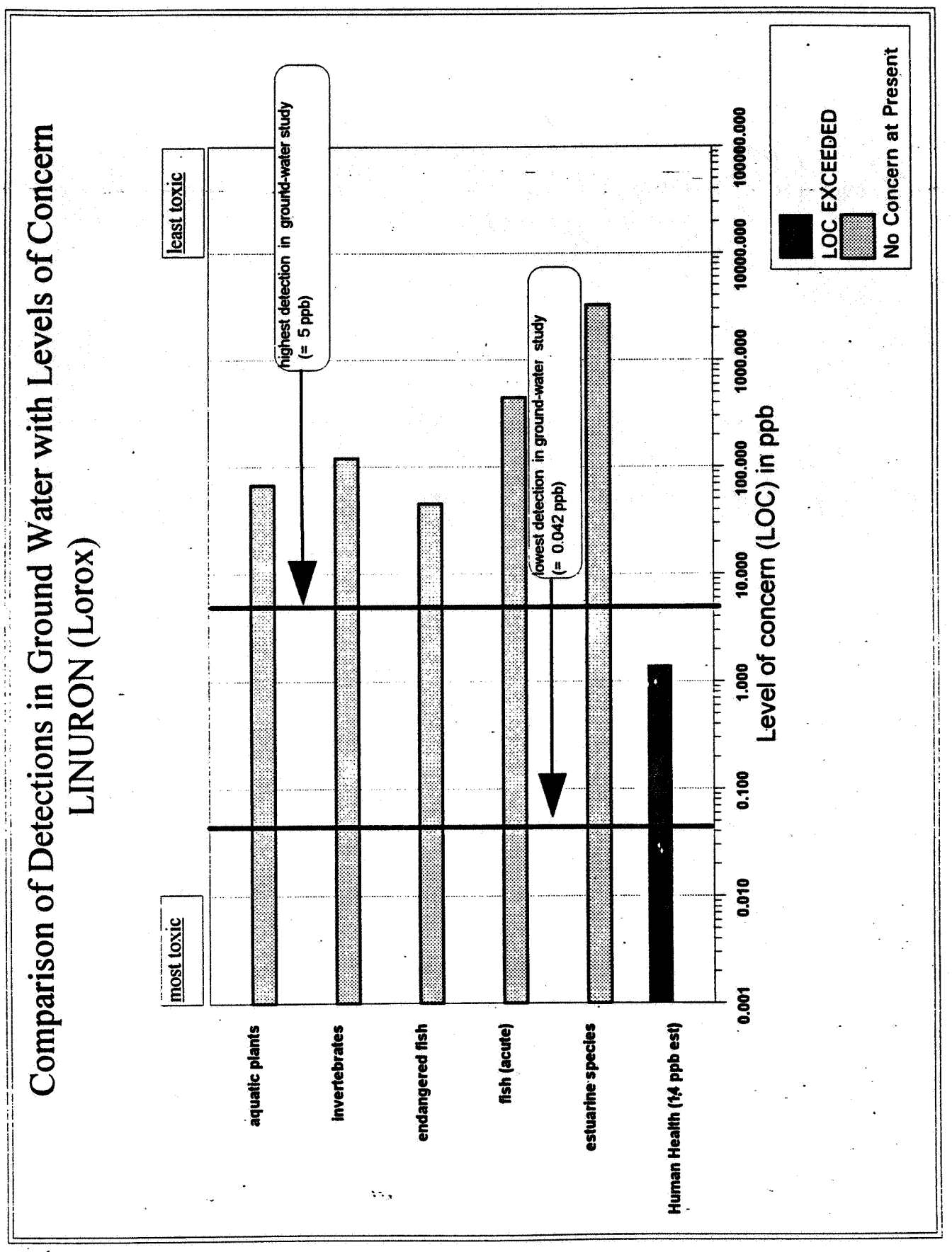

Comparison of Detections in Ground Water with Levels of Concern
LINURON (Lorox)
most toxic
least toxic
highest detection in ground-water study
(= 5 ppb)
lowest detection in ground-water study
(= 0.042 ppb)
aquatic plants
invertebrates
endangered fish
fish (acute)
estuarine species
Human Health (1.4 ppb est)
0.001
0.010
0.100
1.000
10.000
100.000
1000.000
10000.000
100000.000
Level of concern (LOC) in ppb
LOC EXCEEDED
No Concern at Present

TABLE A. GENERIC DATA REQUIREMENTS FOR LINURON (3-(3,4-Dichlorophenyl)-1-methoxy-1-methylurea)

Data Requirement	Use Pattern[1]	Data Requirement Satisfied?	Bibliographic Citation	Additional Data Required?
40 CFR §158.290 ENVIRONMENTAL FATE				
DEGRADATION STUDIES -- LABORATORY:				
161-1. Hydrolysis	A, B, G	Yes	MRID# 40916201	No
Photodegradation - :				
161-2. In Water	A, B, G	Yes	MRID# 40103601	No
161-3. On Soil	A, G	Yes	MRID# 40171701	No
161-4. In Air	A	Waived[2]	----	No
METABOLISM STUDIES:				
162-1. Aerobic Soil	A, B, G	Yes	MRID# 00125244 MRID# 41625401	No
162-2. Anaerobic Soil	A	Yes	MRID# 40142501	No
162-3. Anaerobic Aquatic	G	Yes	MRID# 40142501	No
162-4. Aerobic Aquatic	N/A	No	----	No
MOBILITY STUDIES:				
163-1. Leaching and Adsorption/Desorption	A, B, G	No[3]	MRID# 00148443 Accession # 255830	Yes
163-2. Volatility (Lab)	A	Waived	----	No
163-3. Volatility (Field)	A	Waived	----	No
DISSIPATION STUDIES -- FIELD:				
164-1. Terrestrial (Soil)	A, B	No[4]	MRID# 41734201 MRID# 41734202 MRID# 42422801 (Storage Stability)	Yes

3

TABLE A. GENERIC DATA REQUIREMENTS FOR LINURON (3-(3,4-Dichlorophenyl)-1-methoxy-1-methylurea)

Data Requirement	Use Pattern[1]	Data Requirement Satisfied?	Bibliographic Citation	Additional Data Required?
40 CFR §158.290 ENVIRONMENTAL FATE				
164-2. Aquatic (Sediment)	N/A	No	----	No
164-3. Forestry	N/A	No	----	No
164-4. Combination and Tank Mixes	N/A	No	----	No
164-5. Soil, Long-Term	N/A	No	----	No
ACCUMULATION STUDIES:				
165-1. Rotational Crops (Confined)	A	Yes[5]	MRID# 40730101	No
165-2. Rotational Crops (Field)	A	Waived[6]	----	No
165-3. Irrigated Crops	N/A	No	----	No
165-4. In Fish	A, B, G	Yes	Acc.# 258300	No
165-5. Aquatic Non-Target Organisms	N/A	No	----	No
GROUNDWATER MONITORING:				
166-1. Small Prospective	N/A	No	----	Yes[7]
166-2. Small Retrospective	N/A	No	----	No
166-3. Large Retrospective	N/A	No	----	No
SURFACE WATER:				
167-1. Field Runoff	N/A	No	----	No
167-2. Surface Water Monitoring	N/A	No	----	No

TABLE A. GENERIC DATA REQUIREMENTS FOR LINURON (3-(3,4-Dichlorophenyl)-1-methoxy-1-methylurea)

Data Requirement	Use Pattern[1]	Data Requirement Satisfied?	Bibliographic Citation	Additional Data Required?
40 CFR §158.440 SPRAY DRIFT				
201-1. Droplet Size Spectrum	A, B	No	----	Reserved[8]
202-2. Drift Field Evaluation	A, B	No	----	Reserved[8]

FOOTNOTES:

[1] The Use Patterns codes are: A = Terrestrial Food; B = Terrestrial Nonfood; C = Aquatic Food Crop; D = Aquatic Non-food; E = Greenhouse Food Crop; F = Greenhouse Non-food; G = Forestry; H = Domestic Outdoor; I = Indoor; J = Indirect Discharge Aquatic Use; and N/A = Not Applicable.

[2] The Photodegradation in Air (161-4), Volatility (Laboratory; 163-2) and Volatility (Field; 163-3) data requirements were waived because the reported vapor pressure of linuron is 1.5×10^{-5} mm Hg at 24° C.

[3] The Leaching/Adsorption/Desorption (163-1) data requirement is not fulfilled because validated information on the K_ds for the major linuron degradates formed under anaerobic conditions (desmethoxy linuron, desmethoxy monolinuron, norlinuron) is not currently available. Adsorption coefficients (K_ds) may be determined using batch equilibrium test methodology.

[4] The Terrestrial Field Dissipation (164-1) data requirement is not fulfilled because the patterns of formation and decline of total linuron residues could not be assessed; and field test procedures and analytical methodology were not completely described. The California study may be upgradeable if additional information on study methods and early soil sample results can be provided; however, the Delaware study cannot be upgraded because the consistent presence of linuron in the control plot confounds accurate assessment of the pattern of formation and decline of total linuron residues. A new study is needed to satisfy the data requirement.

[5] The Confined Rotational Crop (165-1) data requirement was transferred to RCB/HED (effective 2/22/93). Inquiries regarding this data requirements should be directed to RCB/HED.

[6] Information on the Field Rotational Crop (165-2) data requirement waiver may be obtained from RCB/HED (Review Dated 3/20/90).

[7] EFGWB recommends prospective ground-water monitoring studies be conducted for linuron. In order to determine the potential of this chemical to leach to ground water, studies should be conducted in coarse-textured soils with low organic matter and in soils more representative of typical linuron use areas.

[8] This study may be required by EFGWB if toxicological considerations are indicated by either EEB and/or HED.

greater than atrazine.

Linuron is not currently regulated under the Safe Drinking Water Act (SDWA). Therefore, no MCL has been established for it and water supply systems are not required to sample and analyze for it. In addition, no drinking water health advisories have been established for linuron. However, based upon the Reference Dose, EFGWB has (for screening purposes only-refer to the Ground Water Assessment) estimated a relatively low lifetime health advisory for linuron of 6.0 ug/L. Although the available data suggests that the average annual linuron concentration will generally be well below 6 ug/L, the available data do not necessarily include those from watersheds that drain high linuron use areas. In addition, the relatively low to intermediate soil to water partitioning of linuron indicates that the primary treatment processes employed by most water supply systems to remove suspended sediment may not always be completely effective in removing linuron. Consequently, EFGWB does have some moderate concerns over potential risks of linuron to surface water source supply systems.

As a precaution for protecting human health, EFGWB recommends that re-registration of linuron be contingent upon the registrants agreeing to fund limited monitoring programs for linuron in surface source water supply systems which drain watersheds which typically receive high linuron applications. The funding could possibly include or completely consist of reimbursement of selected water supply systems for including linuron in the analyses of samples collected in compliance with the requirements of the SDWA. The numbers and locations of the systems for which monitoring would be funded can be negotiated as well as the duration of the monitoring programs.

If a decision is made to generate a labeling surface water advisory for linuron, EFGWB recommends the following wording:

Linuron can contaminate surface water through spray drift from ground spraying. Under some conditions, linuron may also have a high potential for runoff into surface water (via both dissolution in runoff water and adsorption to eroding soil), for several weeks post-application. These include poorly draining or wet soils with readily visible slopes toward adjacent surface waters, frequently flooded areas, areas over-laying extremely shallow ground water, areas with in-field canals or ditches that drain to surface water, areas not separated from adjacent surface waters with vegetated filter strips, and highly erodible soils cultivated using poor agricultural practices such as conventional tillage and down the slope plowing.